IEC 61131-6

Edition 1.0 2012-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Programmable controllers –
Part 6: Functional safety

Automates programmables –
Partie 6: Sécurité fonctionnelle

IEC 61131-6:2012

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CONTENTS

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PROGRAMMABLE CONTROLLERS –

Part 6: Functional safety

FOREWORD

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International Standard IEC 61131-6 has been prepared by subcommittee 65B: Measurement and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation.

The text of this standard is based on the following documents:

FDIS	Report on voting
65B/831/FDIS	65B/850/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61131 series can be found, under the general title *Programmable controllers*, on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

General

IEC 61131 series consists of the following parts under the general title *Programmable controllers*:

Part 1: General information
Part 2: Equipment requirements and tests
Part 3: Programming languages
Part 4: User guidelines
Part 5: Communications
Part 6: Functional safety
Part 7: Fuzzy control programming
Part 8: Guidelines for the application and implementation of programming languages

This Part of IEC 61131 series constitutes Part 6 of a series of standards on programmable controllers and the associated peripherals and should be read in conjunction with the other parts of the series.

As this document is the FS-PLC product standard, the provisions of this part should be considered to govern in the area of programmable controllers and their associated peripherals.

Compliance with Part 6 of IEC 61131 cannot be claimed unless the requirements of Clause 4 of this part are met.

Terms of general use are defined in Part 1 of IEC 61131. More specific terms are defined in each part.

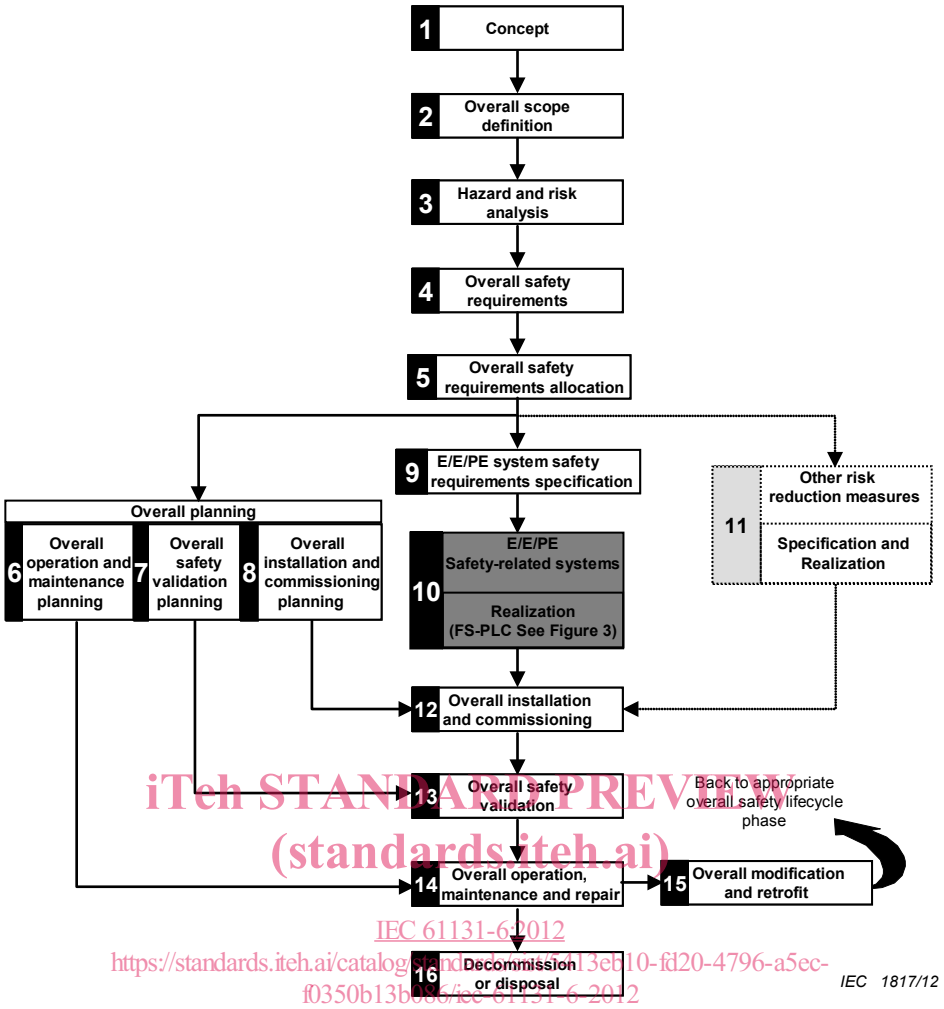
In keeping with 1.1 of IEC 61508-1:2010, this part encompasses the product specific requirements of IEC 61508-1, 61508-2 and 61508-3 as pertaining to programmable controllers and their associated peripherals.

This document's intent is to follow the IEC 61508 series structure, in principle. But some aspects do not have a direct correlation and thus need to be addressed somewhat differently. In part, this is due to addressing hardware, software, firmware, etc. in a single document.

Framework of this part

IEC 61508-1:2010, Figure 2 is included here, and is designated Figure 1. It has been adjusted to show how an FS-PLC fits into the overall E/E/PE safety-related system safety lifecycle. Though Figure 1 box 10 includes sensors, logic subsystem and final elements (e.g. actuators), from the viewpoint of IEC 61508-1, the FS-PLC is given emphasis here by including a reference to Figure 3.

As such, the Realization Phase, Figure 1, box 10, embodies only the logic subsystem, from this part's perspective.



NOTE 1 Activities relating to verification, management of functional safety and functional safety assessment are not shown for reasons of clarity but are relevant to all overall, E/E/PE system and software safety lifecycle phases.

NOTE 2 The phases represented by box 11 is outside the scope of this standard.

NOTE 3 IEC 61508-2 and IEC 61508-3 deal with box 10 (realization) but they also deal, where relevant, with the programmable electronic (hardware and software) aspects of boxes 13, 14 and 15.

NOTE 4 See IEC 61508-1, Table 1 for a description of the objectives and scope of the phases represented by each box.

NOTE 5 The technical requirements necessary for the overall operation, maintenance, repair Modification, retrofit and decommissioning or disposal will be specified as part of the information provided by the supplier of the E/E? PE safety-related system and its elements and components.

Figure 1 – FS-PLC in the overall E/E/PE safety-related system safety lifecycle phases

The areas included in this part are FS-PLC safety lifecycle management, functional safety requirements allocation, and development planning; with the major emphasis on the Realization Phase (Box 10) of the overall safety lifecycle, shown in Figure 1. The assumption of this part is that the FS-PLC is utilized as a logic subsystem for the overall E/E/PE system.

The Figure 1, Realization (box 10), includes:

- the allocation of the FS-PLC safety aspects to FS-PLC hardware, software or firmware, or any combination,
- FS-PLC hardware architectures,
- verification and validation activities at the FS-PLC level,
- FS-PLC modification requirements,
- operation and maintenance information for the FS-PLC user,
- information to be provided by the FS-PLC manufacturer for the user.

PROGRAMMABLE CONTROLLERS –

Part 6: Functional safety

1 Scope

This Part of the IEC 61131 series specifies requirements for programmable controllers (PLCs) and their associated peripherals, as defined in Part 1, which are intended to be used as the logic subsystem of an electrical/electronic/programmable electronic (E/E/PE) safety-related system. A programmable controller and its associated peripherals complying with the requirements of this part is considered suitable for use in an E/E/PE safety-related system and is identified as a functional safety programmable logic controller (FS-PLC). An FS-PLC is generally a hardware (HW) / software (SW) subsystem. An FS-PLC may also include software elements, for example predefined function blocks.

An E/E/PE safety-related system generally consists of sensors, actuators, software and a logic subsystem. This part is a product specific implementation of the requirements of the IEC 61508 series and conformity to this part fulfils all of the applicable requirements of the IEC 61508 series related to FS-PLCs. While the IEC 61508 series is a system standard, this part provides product specific requirements for the application of the principles of the IEC 61508 series to FS-PLC.

This Part of the IEC 61131 series addresses only the functional safety and safety integrity requirements of an FS-PLC when used as part of an E/E/PE safety-related system. The definition of the functional safety requirements of the overall E/E/PE safety-related system and the functional safety requirements of the ultimate application of the E/E/PE safety-related system are outside the scope of this part, but they are inputs for this part. For application specific information the reader is referred to standards such as the IEC 61511 series, IEC 62061, and the ISO 13849 series.

This part does not cover general safety requirements for an FS-PLC such as requirements related to electric shock and fire hazards specified in IEC 61131-2.

This part applies to an FS-PLC with a Safety Integrity Level (SIL) capability not greater than SIL 3.

The objective of this part is:

- to establish and describe the safety life-cycle elements of an FS-PLC, in harmony with the general safety life-cycle identified in IEC 61508-1, -2 and -3;
- to establish and describe the requirements for FS-PLC HW and SW that relate to the functional safety and safety integrity requirements of a E/E/PE safety-related system;
- to establish evaluation methods for a FS-PLC to this part for the following parameters/criteria:
  - a Safety Integrity Level (SIL) claim for which the FS-PLC is capable,
  - a Probability of Failure on Demand (PFD) value,
  - an average frequency of dangerous failure per hour value (PFH),
  - a value for the safe failure fraction (SFF),
  - a value for the hardware fault tolerance (HFT),
  - a diagnostic coverage (DC) value,
  - a verification that the specified FS-PLC manufacturer's safety lifecycle processes are in place,

  - the defined safe state,
  - the measures and techniques for the prevention and control of systematic faults, and
  - for each failure mode addressed in this part, the functional behaviour in the failed state;
- to establish the definitions and identify the principal characteristics relevant to the selection and application of FS-PLCs and their associated peripherals.

This part is primarily intended for FS-PLC manufacturers. It also includes the critical role of FS-PLC users through the user documentation requirements. Some user guidelines for FS-PLCs may be found in IEC 61131-4.

The requirements of ISO/IEC Guide 51 and IEC Guide 104, as they relate to this part, are incorporated herein.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60947-5-1:2003, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC/TS 61000-1-2:2008, *Electromagnetic compatibility (EMC) – Part 1-2: General – Methodology for the achievement of functional safety of electrical and electronic systems including equipment with regard to electromagnetic phenomena*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61131-1:2003, *Programmable controllers – Part 1: General information*

IEC 61131-2:2007, *Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61131-4:2004, *Programmable controllers – Part 4: User guidelines*

IEC 61326-3-1:2008, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for*

equipment intended to perform safety-related functions (functional safety) – General industrial applications

IEC 61326-3-2:2008, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-2: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – Industrial applications with specified electromagnetic environment*

IEC 61508-1:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements*

IEC 61508-2:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems*

IEC 61508-3:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 3: Software requirements*

IEC 61508-6:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3*

IEC 61784-3:2010, *Industrial communication networks – Profiles – Part 3: Functional safety fieldbuses – General rules and profile definitions*

IEC 62443 (all parts), *Industrial communication networks – Network and system security*

IEC Guide 104:2010, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC Guide 51:1999, *Safety aspects – Guidelines for their inclusion in standards*

EN 50205:2002, *Relays with forcibly guided (mechanically linked) contacts*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
application program
application software
part of the software of a programmable electronic system that specifies the functions that perform a task related to the EUC rather than the functioning of, and services provided by the programmable device itself

[SOURCE: IEC 61508-4:2010, 3.2.7]

3.2
application specific integrated circuit
ASIC
integrated circuit designed and manufactured for specific function, where its functionality is defined by the product developer

[SOURCE: IEC 61508-4:2010, 3.2.15]

3.3
architecture
specific configuration of hardware and software elements in a system

[SOURCE: IEC 61508-4:2010, 3.3.4]

3.4
availability
the probability that an item is able to perform its intended function, expressed as a decimal value between zero and one

EXAMPLE A = 0,9 means that a product is available 90 % of the time.

Note 1 to entry: For $\lambda T << 1$, $A = 1 - \lambda T$, See 3.23.

3.5
average frequency of a dangerous failure per hour
PFH
average frequency of a dangerous failure of an E/E/PE safety-related system to perform the specified safety function over a given period of time

Note 1 to entry: The term “probability of dangerous failure per hour” is not used in this standard but the acronym PFH has been retained but when it is used it means “average frequency of dangerous failure [h]”.

Note 2 to entry: From a theoretical point of view, the PFH is the average of the unconditional failure intensity, also called failure frequency, and which is generally designated *w(t)*. It should not be confused with a failure rate (see Annex B of IEC 61508-6:2010).

Note 3 to entry: When the E/E/PE safety-related system is the ultimate safety layer, the PFH should be calculated from its unreliability $F(T)=1-R(t)$ (see failure rate above). When it is not the ultimate safety-related system its PFH should be calculated from its unavailability $U(t)$ (see PFD, 3.38). PFH approximations are given by $F(T)/T$ and 1/MTTF in the first case and 1/MTBF in the second case.

Note 4 to entry: When the E/E/PE safety-related system implies only quickly repaired revealed failures then an asymptotic failure rate λ_{as} is quickly reached. It provides an estimate of the PFH.

[SOURCE: IEC 61508-4:2010, 3.6.19]

3.6
black channel
parts of a communication channel which are not designed or validated according to the IEC 61508 series

Note 1 to entry: See: 7.4.11.2 of IEC 61508-2:2010.

3.7
channel
element or group of elements that separately implement an element safety function

EXAMPLE A two-channel (or dual-channel) configuration is one with two channels that independently perform the same function.

Note 1 to entry: The term can be used to describe a complete system, or a portion of a system (for example, sensors or final elements).

[SOURCE: IEC 61508-4:2010, 3.3.6]

3.8
common cause failure
CCF
failure, that is the result of one or more events, causing concurrent failures of two or more separate channels in a multiple channel system, leading to system failure

[SOURCE: IEC 61508-4:2010, 3.6.10]

3.9
cyber security
protection of data in computer and information systems from loss or corruption due to intentional or unintentional activities by unauthorized or malicious individuals